Docket No.: H0498.70112US01
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Charles M. Lieber, et al.
Serial No.:	10/812,653
Confirmation No.:	3416
Filed:	March 29, 2004
For:	NANOSCOPIC WIRE-BASED DEVICES AND ARRAYS
Examiner:	H. Weiss
Art Unit:	2814

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Dated: 9/1/09 Signature: Angelo M. Griffith

APPEAL BRIEF

Mail Stop Appeal Brief - Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Madam:

This Appeal Brief is filed under 37 C.F.R. §41.37(a) and pursuant to the Notice of Appeal filed in this case on July 2, 2009. The fees required under 37 C.F.R. §41.20(b)(2) are dealt with in the accompanying Transmittal of Appeal Brief.

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This brief contains items under the following headings as required by 37 C.F.R. §41.37 and M.P.E.P. §1205.02:

I. REAL PARTY IN INTEREST (37 C.F.R. §41.37(c)(1)(i))

The real party in interest in this application is the assignee, President and Fellows of Harvard College, a university having a place of business at 17 Quincy Street, Cambridge, Massachusetts 02138.

II. RELATED APPEALS AND INTERFERENCES (37 C.F.R. §41.37(c)(1)(ii))

There are no other appeals, interferences, or judicial proceedings which will directly affect or be directly affected by or have a bearing on the Board's decision in this appeal.

III. STATUS OF CLAIMS (37 C.F.R. §41.37(c)(1)(iii))

A. Total Number of Claims in Application

This application was initially filed with 89 claims (claims 1-89). There is currently one claim pending and under consideration. The status of each of the claims as initially filed is summarized below. A copy of the claim as pending is attached as Appendix A.

B. Current Status of Claims

1. Claims canceled: 1-122.
2. Claims withdrawn from consideration but not canceled: None.
3. Claims pending: 123.

4. Claims allowed: None.

5. Claims rejected: 123.

C. Claims on Appeal

The only claim on appeal is claim 123.

IV. STATUS OF AMENDMENTS (37 C.F.R. §41.37(c)(1)(iv))

No amendments to the claims or the specification have been filed subsequent to the amendments filed on October 24, 2008.

V. SUMMARY OF CLAIMED SUBJECT MATTER (37 C.F.R. §41.37(c)(1)(v))

The present invention as defined by the claim on appeal is directed to articles of manufacture, such as electronic memory elements, made from nanoscopic wires, such as carbon nanotubes. Such electronic memory elements, useful for storing data, are formed from "crossbar junctions," which are the intersections of a conductor and at least one nanoscopic wire (page 6, lines 9-11o f the instant application). In some cases, a plurality of conductors and a plurality of nanoscopic wires may be crossed, thereby leading to a regular array of such electrical crossbar junctions (page 6, lines 11-14). In some cases, the conductors themselves may also be nanoscopic wires (page 7, lines 10-12).

An example of such an array, which is an embodiment of the invention as recited in the rejected claim, is shown in Fig. 8 of the application, reproduced below. In this figure, first wires 201 and 202 (e.g., a carbon nanotube in this embodiment) are crossed over second wires 203 and 204 (e.g., other carbon

nanotubes) to form four such crossbar junctions (page 8, line 31 to page 9, line 4). It should be noted that in this figure, for some junctions, the intersecting wires do not actually come into contact with each other (e.g., wires 201 and 203), and there is a small gap between the wires (page 9, lines 5-10). In other cases, however, the wires do come into contact with each other (e.g., wires 201 and 204) (page 9, lines 5-10). Both such arrangements define intersections forming unique data storage elements (page 9, lines 11-13).

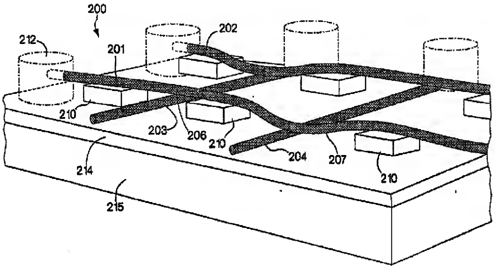


Fig. 8

Each of the crossbar junctions can independently serve as a data storage element, being switchable between different states ("on" and "off" data states) (page 6, lines 11-12). No auxiliary circuitry is necessary to define these different states (page 6, lines 13-14). Instead, each of the junctions is able to store data by maintaining two different states, without the need for energy to be applied to maintain either state (page 10, lines 20-23). The "on" state can be defined as a first state when the nanoscopic wire deforms to electrically contact the conductor, and the "off" state can be defined as a second state where the nanoscopic wire and the conductor are free of electrical contact, i.e., are separate from each other (page 11,

lines 3-11). In particular, the junction includes stable minima at both the "off" and "on" states. When a nanoscopic wire deforms to create an electrical contact with the conductor to create the "on" state, the nanoscopic wire is capable of maintaining its deformed state without the need for additional energy to be applied. In the "off" state, the nanoscopic wire remains separately supported above the conductor, without coming into contact with the conductor, and without the need to apply additional energy (page 11, lines 3-11).

To switch a junction from an "off" state to an "on" state, the nanoscopic wire and the conductor are biased with dissimilar electrical potentials (e.g., a positive and negative potential). This causes the nanoscopic wire and the conductor to become attracted towards each other, and the nanoscopic wire is thus caused to deform to come into contact with the conductor (page 11, lines 29-34). The junction can be likewise switched from an "on" state to an "off" state by biasing the nanoscopic wire and the conductor with a similar electrical potential, e.g. the same polarity. This causes the nanoscopic wire and the conductor to repel and to physically separate, leaving the junction in the "off" state (page 11, line 34 to page 12, line 1).

Fig. 8, reproduced above, illustrates the operation of this switching behavior. In this figure, the "off" state is shown by the junction of wires 201 and 203 with the wires being separated. As a dissimilar electrical potential is established between the wires that causes them to become attracted them to each other, wire 201 is deflected downwards until it contacts the lower wire, defining the "on" state. Applying a similar electrical potential to the wires causes them to physically separate, returning the junction to the "off" state as shown by the junction of wires 201 and 203 (page 10, lines 16-25; page 11, line 29 to page 12, line 1).

VI. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL (37 C.F.R. §41.37(c)(1)(vi))

A. Whether claim 123 is unpatentable under 35 U.S.C. §103(a) as obvious over Melzer, *et al.*, U.S. Pat. No. 5,774,414 ("Melzner") and Brandes, *et al.*, U.S. Pat. No. 6,445,006 ("Brandes").

VII. ARGUMENT (37 C.F.R. §41.37(c)(1)(vii))

A. Claim 123 is not unpatentable over the combination of Melzner and Brandes.

The Examiner rejected claim 123 over the combination of Melzer, *et al.*, U.S. Pat. No. 5,774,414 ("Melzner") and Brandes, *et al.*, U.S. Pat. No. 6,445,006 ("Brandes"). The *sole* reasoning the Examiner states in making this rejection as to why and how one of ordinary skill in the art would have combined these references and bridged the conceptual and technical gap separating the claimed invention from the state of the art is that one of ordinary skill in the art would have been motivated "to capitalize on the semiconducting properties of carbon nanotubes." This vague statement does not articulate a sufficient reason for a person of ordinary skill to arrive at the presently claimed invention in view of this combination of references.

In addition, as Melzner is directed to memory devices, while Brandes is directed to sensors—devices that are very different in structure and function as is appreciated by those of ordinary skill in the art—it is not seen, and the Examiner does not explain, how or why one of ordinary skill in the art would even attempt to make this combination of references, let alone how or why one could have combined these teachings to arrive at the specific device recited in the rejected claim. Indeed, the Examiner does not even provide rational support for his

generalized reasoning that one of ordinary skill in the art would combine a memory device with a sensor to capitalize on the semiconducting properties of carbon nanotubes. Instead, this rejection appears to be based on classic hindsight reasoning: using the claimed invention as a blueprint for selecting disparate prior art references that each separately have some features in common with the claimed invention, without providing justification as to why or how one of ordinary skill in the art would have attempted to combine the references without knowledge of the claimed invention. Accordingly, as further explained below, this rejection is improper, and should be reversed.

1. The rejection of claim 123 should be reversed because the Examiner has not established a *prima facie* case of obviousness over the combination of Melzner and Brandes.

The Examiner has not met his burden to provide an explicit reason for making the combination of Melzner and Brandes in formulating his *prima facie* obviousness rejection, as is required under *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398 (2007) (quoting *In re Kahn*, 441 F.3d 977 (Fed. Cir. 2006) ("[R]ejections on obviousness grounds cannot be sustained by mere conclusory statements; instead, there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness.")). In particular: "To facilitate review, this analysis should be made explicit." *Ibid.* See also M.P.E.P. §2143. Specifically, the Examiner has repeatedly stated that the rationale to make the combination of Melzner and Brandes is to "capitalize on the semiconducting properties of carbon nanotubes." See, e.g., the Office Action dated January 2, 2009, Paragraph 2; the Office Action dated April 25, 2008, Paragraph 8; the Office Action dated January 28, 2008; the Office Action of October 13, 2006, Paragraph 3; the Office Action of February 21, 2006, Paragraph 6; or the Office Action

mailed July 26, 2005, Paragraph 4; see also the Office Action mailed November 19, 2004, Paragraph 10 (identical rationale, but with a difference reference).

The term "capitalize" is vague and general, and could mean any number of different things. For example, one of ordinary skill in the art, in attempting to "capitalize" on the semiconductor properties of carbon nanotubes, may be motivated to produce shorter carbon nanotubes or larger carbon nanotubes. Or, perhaps the person of ordinary skill in the art would look for ways to decrease the costs of manufacturing or selling such nanowires. The Examiner has provided no rational explanation as to why a person of ordinary skill in the art, in reading Melzner (which does not even disclose or suggest a carbon nanotube), would be motivated to modify Melzner in such a way as to incorporate the teachings of Brandes in a way that leads to the claimed invention, and has pointed to no statement in Melzner or Brandes or anywhere else in the record that would support a combination or modification that results in the invention as claimed.

It appears that the Examiner has taken the phrase "to capitalize on the semiconducting properties of carbon nanotubes" from Brandes. See col. 7, line 67 to col. 8, line 2, which states "A variety of electronic devices can be fabricated to capitalize on the semiconducting properties of carbon nanotubes, using a catalytic growth process." To the extent this is the case, the Examiner's reliance is misplaced, as it appears that this statement was taken out of context. In Brandes, this statement is focused only on electronic devices that were appreciated at the time as being able to be fabricated using carbon nanotubes. In fact, the actual paragraph from Brandes is as follows (col. 7, line 65 to col. 8, line 2):

> There is an increasing body of evidence that carbon nanotubes, if free of defects, possess a small bandgap and can be readily doped. A variety of

> electronic devices can be fabricated to capitalize on the semiconducting properties of carbon nanotubes, using a catalytic growth process.

There is no teaching or suggestion in either Brandes or Melzner that electronic memory is an electronic device that can be fabricated using carbon nanotubes. Thus, the basis for making the combination of Melzner and Brandes as articulated by the Examiner is classic hindsight, since it assumes as being true that which it tries to prove, i.e. the present Applicants' success in inventing a memory device based on carbon nanotubes. This is both legally impermissible and logically fallacious.

The Examiner's vague and incomplete reasoning stands in stark contrast to the specific showings required for establishing a *prima facie* case of obviousness under the Patent Office's "Examination Guidelines for Determining Obviousness Under 35 U.S.C. 103 in View of the Supreme Court Decision in KSR International Co. v. Teleflex Inc.," 72 Fed. Reg. 57526 (10 Oct. 2007), now set forth in M.P.E.P. §2143, implemented in the wake of the Supreme Court's decision in *KSR*. Applying the guidelines of M.P.E.P. §2143, it appears that the rationale for the Examiner's rejection implicates M.P.E.P. §2143(a) as purportedly "combining prior art elements according to known methods to yield predictable results." However, in order to support a rejection under M.P.E.P. §2143(a):

> Office personnel *must* articulate the following:
>
> > (1) a finding that the prior art included each element claimed, although not necessarily in a single prior art reference, with the only difference between the claimed invention and the prior art being the lack of actual combination of the elements in a single prior art reference;

> (2) a finding that one of ordinary skill in the art could have combined the elements as claimed by known methods, and that in combination, each element merely performs the same function as it does separately;
>
> (3) a finding that one of ordinary skill in the art would have recognized that the results of the combination were predictable; and
>
> (4) whatever additional findings based on the Graham factual inquiries may be necessary, in view of the facts of the case under consideration, to explain a conclusion of obviousness. [Emphasis added]

The Examiner has made no such findings, as he is required to do under any of at least M.P.E.P. §2143(a)(1), (2), and (3). As discussed further below, the elements of Melzner and Brandes perform substantially different functions in their respective devices: Melzner is directed to a memory device, while Brandes is directed to a sensor. The Examiner has not provided any explanation as to why or how components of devices with different functions (storage of data versus the sensing of mechanical forces) perform the same functions as each does separately when combined together, or how such a composite device would operate and what functions it would be able to perform. Further, there is nothing cited by the Examiner to support the conclusion that one of ordinary skill in the art would have found the results of the combining Brandes and Melzner to be predictable.

Accordingly, the rationale proffered falls far short of establishing a *prima facie* case of obviousness under the Patent Office's own examination guidelines, and finds no support in the teachings of Brandes and Melzner, or in any other teachings or findings of record. Fundamentally, the burden is on the Examiner to provide some articulate reason with some rational underpinning as to why one of ordinary skill in the art would combine the references relied upon in the *prima facie* case of obviousness, as the Supreme Court noted in *KSR*, As demonstrated

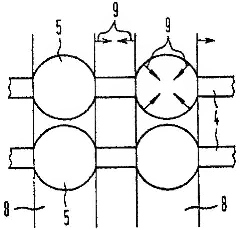
above, the Examiner has not met this burden in his rejection of claim 123, and accordingly the rejection of claim 123 should be reversed.

2. The rejection of claim 123 should be reversed because one of ordinary skill in the art would not have had any reason to combine Melzner and Brandes.

Contrary to the conclusory, unsupported rationale provided by the Examiner that in contemplating Meltzer and Brandes, one would have combined their teachings "to capitalize on the semiconducting properties of carbon nanotubes," in fact, one of ordinary skill in the art at the time of the Applicants' invention would not have had any logical reason to combine Melzner, directed to a semiconductor memory device, with Brandes, directed to carbon-based nanotube sensors.

Melzner nowhere discloses or suggests use of a "nanotube," let alone a "carbon nanotube," as Melzner is instead directed to semiconductor memory devices where a plurality of memory cells is each constructed using a micromechanical diaphragm (a circular disc) that is placed under compressive stress (col. 1, lines 49-61). See Fig. 2D of Melzner, reproduced below:

FIG 2D



In this figure, which is a top view of Melzner's device, each memory cell is formed from a circular diaphragm or disc 5, which is placed under compressive

stress. The memory cells are defined at the intersections of conductor tracks 4 (running horizontally in Fig. 2D) that pass over trenches 8 (running vertically in Fig. 2D). The diaphragm is typically formed from silicon (col. 12, lines 12-38). The status of the memory cell depends upon whether the diaphragm is bent upward or downward by a compressive stress, as controlled by the state of electrical contact of the diaphragm with a "sharp point" on a substrate positioned below the diaphragm (col. 10, lines 21-44; col. 11, lines 34-48).

Brandes, on the other hand, is directed to carbon nanotube sensors, and does not teach or suggest use of carbon nanotubes in a memory device. As noted above, the memory devices of Melzner rely on memory cells (disks) at junction points being subjected to compressive forces. While Brandes discloses forming connections between objects such as electrodes with carbon nanotubes, Brandes does not disclose or in any way suggest that the carbon nanotubes can be exposed to any compressive forces, or that they would be expected to be able to withstand such exposure, let alone that exposure to compression would be advantageous or in any way facilitate use of these nanotubes in any sort of electronic device. While Brandes does disclose that carbon nanotubes can move when subjected to a deflecting force (see, col. 9, line 4-col. 10, lines 16), in each case, the force is taught as being applied to a nanotube fixed at only one end (see, e.g., Figs. 11-13 from Brandes, reproduced below, with nanaotubes 810, 908, or 1000 as examples). Accordingly, as would have been understood by one of ordinary skill in the art, the carbon nanotubes in these embodiments of Brandes are not under any compressive stress during movement, since one end of the carbon nanotubes is free to move.

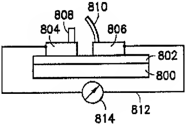


FIG.11

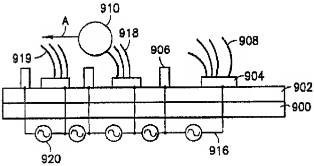


FIG.12

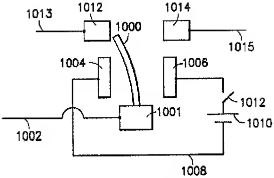


FIG.13

The devices disclosed in Brandes, which involve some movement of a carbon nanotube in order to operate (e.g., a flow sensor, an accelerometer, a ciliated motive driver, and a microelectromechanical relay, see col. 8, line 61 to col. 10, line 10), would each fail to operate if the carbon nanotube was placed under compressive stress is required for the memory elements of Melzner. Accordingly, Brandes does not disclose or suggest a carbon nanotube placed under compressive stress as it would be if substituted for the disks of Melzner, and, if anything, Brandes would teach away from such a configuration.

Brandes also discloses that carbon nanotubes can be made to grow in a variety of directions using an applied electric field (col. 5, line 30-col. 6, line 45). However, in such embodiments, Brandes nowhere discloses or suggests that nanotubes in such devices could be mobile. While Brandes discloses "spot welding" the ends of the nanotube onto a surface after formation (see, e.g., col. 6,

lines 32-39), it nowhere teaches or suggests that after attachment of both ends in this way the nanotubes could move (including experiencing any compressive stress) during use. For example, Brandes discloses pn junction diodes formed by crossing carbon nanotubes (see, e.g., col. 7, line 53 to col. 8, line 60), but does not suggest that such carbon nanotubes are able to move. Indeed, if the carbon nanotubes were free to move in the Brandes pn junction diodes, the device would be rendered unsuited for its intended function, as the "point contact" required within the diode could not be maintained (col. 7, line 55).

Accordingly, one of ordinary skill in the art, in examining Melzner and Brandes, absent the insight gained in hindsight from the Applicants' specification, would not have had a reason to attempt their combination for the above reasons, let alone expect that such a combination would lead to a predictable and desirable outcome. This is not a situation in which there are a finite number of identified, predictable potential solutions where a component of a memory device could be replaced with a component of a sensor with no change in either of their respective functions.

Accordingly, since there would have been no logical reason for a person of ordinary skill in the art to combine Melzner and Brandes, the rejection of claim 123 should be reversed.

3. The rejection of claim 123 should be reversed because the results of the substitution or combination would not have been predictable to a person of ordinary skill in the art nor would have the person of ordinary skill have been able to combine Melzner and Brandes to form a working device with a reasonable expectation of success.

Even if one of ordinary skill in the art were, for the sake of argument, to attempt to combine Melzner and Brandes in a manner leading to the invention

described by claim 123, the performance and function of such a modified device would not have been predictable, and thus, there would have been no reasonable expectation of success. To the contrary, as explained to the Examiner, one of ordinary skill in the art would have reasonably predicted that such an arrangement would not work. For example, it would be expected that substituting the diaphragm-containing conductors of Melzner with the nanotubes of by Brandes would most likely have resulted in a non-functional device.

Indeed, the Applicants, to provide additional evidence supporting their position relating to the lack of predictability, and the absence of a reasonable expectation of making the proposed combination in a manner to arrive at the claimed invention, submitted a Declaration on April 6, 2009 from one of the inventors, Prof. Charles Lieber, stating in part (paragraph 9, page 2) that:

> 9. Even if one were to consider combining of Melzner and Brandes, without the benefit of the disclosure of the [current] Patent Application, one would not predict that an arrangement as disclosed in the Patent Application and as recited in the pending claims would result. In fact, one would predict that such an arrangement would not work. One would expect that substituting the diaphragm-containing conductors of Melzner with nanotubes (as disclosed by Brandes or otherwise), and forming a crossed-conductor array with at least one set of conductors defined by nanotubes, would result in a non-functional device. One would expect that simply applying opposite potentials to a first conductor (wire or nanotube) and a nanotube crossing the first conductor, might at best slightly deflect the nanotube, but would not be sufficient to repeatedly connect and disconnect the first conductor and nanotube. And even if one were to assume that connection/disconnection would be possible in this way, one would not predict that both a "connected" and "disconnected" state of the first conductor and nanotube would each be stable, i.e., that one could apply opposite charge to the two to connect the two, remove application of opposite charge and realize continued connection of the two, then apply like charge to disconnect the two, and remove application of like charge and realize continued disconnection of the two.

> The ability to connect and disconnect the first conductor and nanotube, without auxiliary means other than the electrical connections also used to "read" the connected or disconnected states, and especially the bistability of the system, was not predicted by me to work when first contemplated, and its success in function was a great surprise to me.

The Examiner did not rebut any of these statements with any facts, evidence, or other findings. In fact, the *totality* of the Examiner's written remarks in response to this Declaration (Advisory Action of May 18, 2009) is as follows:

> Continuation of 11. does NOT place the application in condition for allowance because: the Applicants' arguments were not persuasive. The pending claim remains finally rejected for the reasons stated in the final rejection mailed 1/2/2009. After further consideration and under consultation with other Examiner [sic], the declaration filed with the request for reconsideration is considered and will be entered into the record. However, this has not changed the status of the Application.

In conclusion, to the extent that one of ordinary skill in the art would have attempted to combine Melzner and Brandes, the result of such a combination would not have been predictable, and there would have been no reasonable expectation of success in achieving a result having a useful function or advantage over the state of the art. The Examiner has not made any findings or provided any evidence to the contrary. Accordingly, for this additional reason the rejection of claim 123 should be reversed.

VIII. CONCLUSION

For the foregoing reasons, the rejection of claim 123 was improper, and should be reversed.

Dated: 09/01/09

Respectfully submitted,

By ____________________

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APPENDIX A. CLAIMS AS APPEALED (37 C.F.R. §41.37(c)(1)(viii))

1-122. (Cancelled)

123. (Previously Presented) An article, comprising:

an electrical crossbar array defined by a plurality of conductors and a plurality of nanotubes which cross the plurality of conductors at intersections, wherein a plurality of the intersections are unique data storage elements and are switched between at least "on" and "off" readable states by solely applying dissimilar or similar electrical potential to one or more of the conductors and one or more of the nanotubes that define the unique data storage elements, whereby for each of said elements, the one or more nanotubes deforms and electrically connects, or disconnects, respectively, to the one or more conductors to switch the unique data storage element to the "on" or "off" state, respectively, upon the application of the dissimilar or similar electrical potential, and whereby when switched to the "on" or "off" state, the unique data storage element remains in said state absent application of a similar, or dissimilar electrical potential, respectively, to the one or more conductors and the one or more nanotubes defining the unique data storage element, but when a similar, or dissimilar electrical potential, respectively, is applied between the one or more conductors and the one or more nanotubes defining the unique data storage element, the unique data storage element returns to an "off" or "on" state, respectively.

APPENDIX B. EVIDENCE SUBMITTED (37 C.F.R. §41.37(c)(1)(ix))

No evidence pursuant to 37 C.F.R. §§1.130, 1.131, or 1.132 and/or evidence entered by or relied upon by the Examiner that is relevant to this appeal is being submitted.

APPENDIX C. RELATED PROCEEDINGS (37 C.F.R. §41.37(c)(1)(x))

No related proceedings are referenced in Section II. above, hence copies of decisions in related proceedings are not provided.